THE BALLISTIC MISSILE DECISIONS

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The acquisition by the United States of an effective force of intercontinental ballistic missiles was in its narrowest sense the product of a sequence of decisions on two central questions: first, was it technically and economically feasible to do so, and second, was it in the best interests of the nation to do so.

Such questions seem straightforward enough, and viewed from the perspective of today the answers are almost childishly obvious. But they were not and are not simple questions. They involved considerations of national strategy, force structure, resource allocation and institutional interest that were central to the functioning of the American Government. They invoked issues of such complexity that the whole fabric of American society was affected thereby. Finally, at no single instant was it possible to state the issues so precisely that a sequence of specific moves could be laid out and acted upon in response. Nevertheless, there is a tendency in this country to treat the whole ballistic missile issue as though it focused on and then radiated from a single positive decision arrived at during a given moment in early 1954, to assume that later actions were no more than operational extensions of that one decision, to conclude that all preliminaries in the matter were essentially negative reactions to a

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solitary question first answered affirmatively in 1954. That was not at all the true case, of course, but later events tended to reinforce the myth. Owing largely to the fact that the Soviet Union both claimed and demonstrated a ballistic missile capability during 1957,* what may be called the missile question became deeply embedded in American domestic politics from 1958 through 1960. Once it got mixed into a Presidential election, as happened in 1960, dispassionate analysis became very difficult -- or perhaps it is more to the point to say that any attempt at analysis was liable to be given a partisan interpretation. Sub-issues not obviously essential to the main question have further complicated appraisal. Notably, there was a bitter intra-service dispute between various Air Force functions about the proper mode of developing and deploying first generation missiles, there were continuing institutional arguments between the Army and the Navy and the Air Force concerning operational assignments, two groups of scientists and strategists with opposing views on limited war and massive deterrence clashed bitterly, the airplane versus missile and landpower versus seapower debates found new fuel, qualitative and quantitative disagreement about the nature of the Soviet threat and its imminence becam once again a major issue, and through the whole ran a persistent thread of disagreement about the real operational capability of missiles themselves. At the heart of the latter issue and more or less involved in most of the others were arguments about the status of advanced missile technology and the real cost of acquiring it. These varied and complex issues were not concurrently important, of course. Indeed, one or another tended to go into brief hibernation from time to time, only to be revived later.

One central characteristic of "the ballistic missile question" was its inconstancy -- its changeableness. The issues of 1947 were not the issues of 1951 or 1954 or 1957 even though many of them reappeared periodically. Another, scarcely less important characteristic,

*The evidence of Sputnik I was conclusive; less was publicly made of a brief August 1957 TASS announcement that the USSR had successfully fired a "transcontinental" ballistic missile.

was that decisions on what was to be done, and how, were made by different authorities in each instance. And the decisions that evoked significant changes were, in each instance, made without much concern for the long-term effect of those decisions on the institutions they affected. Finally, each of the several primary "decisions" was rationalized on transitory grounds rather than being treated as part of an issue with roots in the past and grave implications for the future. Such rationalization did not even acknowledge, in all cases, the existence of some of the main points in dispute. For example, the inadequacy of technology and a general insufficiency of funding were used as justifications for the 1947 program cutback although institutional influences and shortsighted technical planning appear, in retrospect, to have been at least as important.

THE DECISIONS

Initial work on ballistic missiles in this country was brought on by a reflex reaction to the German use of guided missiles during the closing months of World War II in Europe. It was marked, almost from its start, by disagreements about the functional nature of missiles -- were they air weapons or mostly extensions of artillery -- and about which branch of which service had responsibility for what. For what later became the Air Force, the first move culminated in the post-war establishment of some 26 small-scale missile study and research projects among which were several remote ancestors of later ballistic missiles. But the original American ballistic missile project was not sponsored by the air service and was only indirectly influenced by the V-2. It was Corporal E, intended to be an 11,000-pound, 40-mile-range rocket powered by a gas pressure feed, acid-analine engine invented by the von Kármán-Malina group at Caltech's Jet Propulsion Laboratory in 1943.*

*Corporal E was one of several designs generated by the ORDCIT (Ordnance Department, California Institute of Technology) Project conceived in January 1944. ORDCIT's ultimate objective was a 100-mile missile with a 1000-pound payload and a two-mile accuracy.

The existence of institutional rivalries was a fact of service life well before there were any rational plans for exploiting the scant rocket technology then accessible. The main issue, by 1945, was that the Air Forces looked toward an eventual long-range missile while Ordnance was willing to settle for the best performance that available technology permitted. In any event, the Air Forces in 1946 sponsored a prototype rocket program conducted by Consolidated-Vultee. Its nominal or ultimate goal was a 5000-mile ballistic missile, but it is clear that neither the contractor nor the sponsor had any illusions about the military utility of anything that could be built in the foreseeable future.

As was true of virtually every ballistic missile being studied or developed in 1946, including the Russian, the Consolidated-Vultee design was extrapolated from the German V-2. The ingredients of a long-range missile were mostly there, excepting a nuclear warhead and means of warhead re-entry, but there was general agreement that anything operationally useful was a decade away. (The Germans had actually begun work on a "Berlin-to-New York bombardment rocket" at the time the war ended in Europe, but none of the services was willing to invest enough money or faith in such concepts to disprove or validate them.) In July 1947 the Air Force dropped plans for development. Radio guidance research was continued at a relatively low funding level, however, and resources were found to permit the firing of three prototype missiles actually completed by Consolidated-Vultee. (They were termed "technically successful.") Two long-range missiles with greater apparent near-term potential were continued instead of the ballistic missile. They eventually became the Snark and Navaho programs.

Theodore von Kármán, Frank J. Malina, and Clark B. Millikan were the main project leaders. See Malina, "Origins and First Decade of the Jet Propulsion Laboratory," in The History of Rocket Technology, E. M. Emme (ed.) (Wayne University Press, 1964). The first semiformal division of responsibility gave the Army Air Forces custody of missiles controlled by aerodynamic forces and the Ordnance Corps custody of missiles that, like artillery shells, followed a ballistic path. The Bomarc (with wings) and Nike (semi-ballistic) represent the two subsequent approaches to anti-aircraft defense missiles.

Interestingly enough, at the 15 March 1947 meeting of the Council of Ministers of the U.S.S.R. Stalin directed that a special commission be formed to study the problems of long-range rockets, and by September of that year a pair of preliminary designs for "transatlantic" rockets had been submitted for evaluation. A Russian version of the V-2 was in serial production and a considerably more useful Russian variant, the "Pobedo," was entering its test phase. During the summer of 1947, then, the senior Soviet officials formally affirmed a de facto program of gradual development leading toward a long-range ballistic missile.* The American Air Force, on the other hand, temporarily abandoned the notion of a long-range ballistic rocket and committed additional funds to long-range aerodynamic missiles. The Army rather hesitatingly continued laboratory-scale work in an American extension of the original V-2. This was the Hermes project, which led (in turn) to Hermes C, Redstone, and thence to the Jupiter series missiles of the Army Ballistic Missile Agency.

The logic of the American decision has since been derided, partly in the way of ordinary political bickering, but not very effectively. In 1947, during the period when the United States Air Force was being established as the third service, only a few isolated scientists argued the probability that the Russians could build their own atomic bombs. That the Germans had assimilated all the essential principles of nuclear fission by the time of their defeat, though they lagged badly behind the Americans in application, seemed to count for little.** Russian work was even more thoroughly discounted, and with as little reason; the Russians had been doing nuclear weapons research since 1943.*** Americans in general, and generals and politicians in

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* G. A. Tokaty, "Soviet Rocket Technology," paper presented at September 1961 meeting of the British Interplanetary Society and reprinted in The History of Rocket Technology.

** David Irving, The Virus House (William Kimber, London, 1967).

*** Arnold Kramish, "Developer of Russia's Bomb" (book review) in Science, 25 August 1967, pp. 912-913.

particular, appeared to believe that they had a secure monopoly not merely of atomic weapons and the means of their delivery, but of the science essential to their creation. The belief that a war between the Soviet Union and the United States would in most respects resemble World War II was persistent -- particularly in the notion that a massive production buildup would start with the outbreak of hostilities. The B-36 was entering service, several medium-range jet-propelled bombers were in development, and it seemed no more than reasonable to conclude that the next generation of weapons would include unmanned jet bombers -- aerodynamic missiles -- capable of penetrating any defenses the war-battered Russians could erect. If the evidence for strategic bombing effectiveness was scant, nuclear weapons had changed the equation. Finding a justification for investing in long-range ballistic missiles was not easy; other and more certainly available weapons obviously could do what was necessary to win future wars.

Missiles had been uncertain weapons of desperation in any case, largely ineffective. Those scientists on whom the American services had relied for their advanced technology during the war were not at all unanimous in their opinions, but their most vocal spokesmen -- typified by Vannevar Bush -- ridiculed the possibility of a long-range ballistic rocket: "I say technically I don't think anybody in the world knows how to do such a thing [make an accurate, nuclear armed intercontinental ballistic missile] and I feel confident it will not be done for a long period of time to come."* Technical infeasibility, then, or the assumption of it, was a secondary reason for discounting both the need for and the probability of obtaining ballistic missiles. The principal obstacles were guidance accuracy, thrust requirements, and re-entry -- although it was generally assumed

*Vannevar Bush, who had been chairman of a special committee on new weapons for the Joint Chiefs of Staff, in testimony before the Special Senate Committee on Atomic Energy, December 1945; see Hearings Before the Preparedness Investigating Subcommittee of the Committee on Armed Services, Part I, November 1957 (85th Cong., 1st sess.).

that once the guidance problem had been solved something could be done about the others. That warhead weight and effectiveness were adequately in hand -- at least for the tasks to be assigned to missiles -- was best demonstrated by plans to develop nuclear devices for the long-range cruise missiles (Snark, and somewhat later, Navaho).

By 1950 several events had come together to force a reassessment of earlier missile decisions. The detonation of a Russian nuclear device in August 1949 caused some second thoughts about Soviet backwardness in technology and demolished the attractive myth of American exclusiveness. The onset of fighting in Korea in June 1950 dispensed with the legend that the Eastern Bloc would not challenge the West on the battlefield much as the Berlin blockade (June 1948-May 1949) had signaled a Soviet willingness to test the resolution of the Western Powers in another sort of direct confrontation. In 1950 the Atomic Energy Commission demonstrated experimentally what many nuclear scientists had contended earlier, that both light-weight fission weapons and eventual fusion weapons were feasible.* Some members of the advisory groups to which the Air Force turned for advice began to question whether bombers could successfully penetrate a defense in depth that included both sophisticated air defense electronics and modern anti-bomber missiles. Finally, continuing work on rocket engines, principally by North American Aviation in support of the proposed Navaho missile development, gave greater credibility to predictions that the propulsion units needed for an intercontinental rocket could indeed be developed, although most military experts thought another ten years would be needed to complete the development. Some striking advances in guidance technology had also been made, but again the implications of stable-platform research and of miniaturized electronic components were still uncertain.

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*That the importance of the new technology was recognized at the time (1950) may be deduced from H. S. Truman, Years of Trial and Hope 1946-1952 (Doubleday, New York, 1956), pp. 310-314.

In July 1950 the Army Ordnance Department formally began development of a short-range ballistic rocket, eventually to become Redstone.* Three months earlier Air Force planners had begun a reappraisal of their long-term missile requirements and in its course the Air Council recommended reestablishment of the ballistic rocket project -- on a study level. What was proposed, initially, was a relatively slow-paced development to extend in graduated stages over a period of nearly fifteen years. Underlying the recommendation was an assumption that manned bombers would remain the backbone of strategic air power until at least 1965 and that increasingly more effective long-range missiles would gradually be introduced into the force inventory in the interim. The plan was to buy relatively small forces of subsonic and supersonic Snark and Rascal missiles for the period of the mid-1950s, to acquire Mach 3 Navahos and advanced Rascals for the late 1950s, and to deploy operational intercontinental ballistic missiles toward the middle of the 1960s.** The possibility that missile production could be accelerated during a crisis or after hostilities began had not yet been discarded, but it was not well enunciated either.

Even though considerable progress had been made in missile technology by late 1950, there was increasing evidence that expectations

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*The Redstone project took a 500-mile missile as its original goal but to the disappointment of Wernher von Braun and the "Peenemunde Group" the Army subsequently decided to pursue an evolutionary program based on the Hermes C-1, a much improved model of the V-2. A 200-mile missile, treated as an extension of artillery, thus became the primary goal of the Redstone Arsenal development team. See von Braun, "The Redstone, Jupiter, and Juno" in The History of Rocket Technology, pp. 108-109.

**One justification for missile development was the supposition that missiles could be used to disrupt Soviet air defenses, thus clearing the way for the manned bombers. The use of stand-off missiles, in this era the Rascal, was also counted on to extend the period during which manned bombers would remain the principal devices of strategic warfare.

of being able to move easily from manned aircraft into an era of cruise missiles ("unmanned aircraft" as they were officially called) had been unrealistically optimistic, and it was sensible to expect ballistic missiles to be even more troublesome. In any case, until 1952 a reluctance to depend over much on missiles was evident, and as yet there was no convincing indication that the Russians were paying much attention to them, so arguments based on probable threat tended to founder.

By January 1951 the Air Force had let (to Convair) a contract for initial development of a loosely-defined rocket missile subsequently dubbed Atlas. Like the Army, the Air Force proposed an evolutionary program working from something that resembled a super V-2 to a three-engine vehicle and ultimately to a five-engine intercontinental rocket.* The whole purpose of the deliberate approach was to minimize both risk and investment until, in time, both the technical prospect and the requirement could be clarified. Moreover, in an era when atomic weapons were in relatively short supply there was no compelling reason for entrusting many of them to a low-confidence delivery system. The accuracy requirements specified for the Atlas

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*Interestingly enough, it was not until 1951 that the concepts favored by German rocket scientists in 1945 passed away. Specifically, the attractions of a rocket-boosted glide missile retained their appeal until the availability of relatively large rocket engines was assured. Boost-glide was a way of taking advantage of the kinetic energy imparted to a rocket at launch. But by 1951 it was apparent that a boost-glide missile would combine the several disadvantages of cruise missiles and pure ballistic missiles without providing many of the compensating advantages of either. One great attraction of the glide missile was that it evaded re-entry problems -- though at the cost of making the vehicle more vulnerable to interception and of forcing reliance on some scheme of mid-course and terminal guidance. These problems were rarely discussed in open literature at the time and have been glossed over or misrepresented in many later accounts. See John L. Chapman, Atlas: The Story of a Missile (New York, Harper and Brothers, 1960), pp. 30-36, and E. G. Schweibert, A History of the U.S. Air Force Ballistic Missiles (New York, Praeger, 1965), p. 64.

at that early date were predicated on kiloton-range explosives and thus obliged engineers to plan for ballistic trajectories having considerably less margin for error than seemed reasonable to any but the greatest optimists. The utility of a ballistic missile, even assuming an easy resolution of known technical problems, remained conjectural because of targeting uncertainties that would be markedly less for manned bombers. On such grounds the Air Staff felt no particular urge to put much force behind the slow-tempo program initially approved. Indeed, had it not been for the sudden increase in military appropriations that attended the expansion of fighting in Korea after the Chinese People's Army took a hand at the end of 1950 it is unlikely that the Atlas program would have obtained even the relatively slight financial support needed to get it past the preliminary research stage.

Essentially nothing was done either to accelerate or to expand the Atlas program for more than three years after Convair was awarded its January 1951 contract. Yet in that period some very significant progress was recorded in both nuclear explosives and basic missile technology. In November 1952 the theory of thermonuclear fusion was shown to be correct. North American succeeded in operating test stand versions of relatively high thrust rocket engines that, though intended to boost the Navaho to ramjet flight altitudes, had obvious implications for Atlas. And the United States obtained relatively detailed -- and reliable -- information about the extent of Soviet interest in ballistic missile development.* These events made feasibility somewhat less doubtful and need somewhat more apparent. At about the same time a long-pending reorganization of Air Force functions took effect: the establishment of a separate research and development command and a counterpart reallocation of emphasis at the Air Staff level put some

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*Schwiebert, pp. 57-59. The information came from repatriated German engineers who had not been directly associated with Russian weapons programs for at least two years. It is improbable, though often so stated, that the German engineers were completely unaware that the Russians had plants and programs to which no Germans were admitted. The Germans certainly knew of such programs; what they did not know was the current status or prospect of the independent Russian effort.

of the young Turks of the Air Force into positions of greater influence. More money was made available for high-risk projects -- though not nearly as much as many of the R&D-oriented groups thought necessary. Nevertheless, by 1953 there was some discussion of the possibility of accelerating the established Atlas program. Indeed, it appeared to a few individuals, mostly low in the R&D organization, that on technological grounds alone a long-range ballistic missile was a better prospect for near term development than either Navaho or Snark. Both were in some difficulty, particularly with respect to guidance.

That such discussions led to nothing must in the end be charged to organizational inertia. When the effect of R&D restructuring could be assessed it became apparent that conservatism -- risk aversion -- still was dominant. And distaste for what appeared to be high-risk undertakings seemed to be fully justified; there were no indications that reorganization, of itself, had in any way shortened development times, reduced the extent or effect of program slippages, or otherwise much improved either the availability or the quality of new weapons.

In January 1953 a new administration committed to ending the Korean war and reducing defense expenditures took power in Washington. But any radical change in national defense policy had to await liquidation of the Korean commitment. Fighting did not stop until July 1953, and no public statement on a new concept of national defense policy emerged until December 1953. First expressed by Admiral Arthur W. Radford, new chairman of the Joint Chiefs of Staff, it was expanded and further defined by Secretary of State Dulles a month later, in January 1954. It proposed -- or rather, announced -- a new emphasis on deterrent power, subsequently dubbed the doctrine of massive retaliation, and also expressed a determination not to become involved in Asian wars of the sort this nation had experienced, with general distaste, in Korea. In the simplest terms, the Radford-Dulles doctrine expressed a pronounced aversion to any future commitment of American ground troops to large-scale fighting anywhere on the periphery of the Communist world and the intention of using air power as a substitute.

The determination to reduce the increasingly burdensome costs of national defense by ending duplication of services and programs led the Secretary of Defense to issue instructions, in November 1953, for a detailed review of the several existent Air Force missile programs with a view to canceling those that seemed to have slight promise -- or promise incommensurate with their prospective cost. Trevor Gardner, special assistant for research and development to Air Force Secretary Harold Talbott, was ultimately charged with conducting the review. He named a Strategic Missiles Evaluating Committee under John von Neumann, internationally famous mathematician, and assigned to it a number of outstanding scientists not committed to past concepts.

The study took a curious direction. It should have led to cancelation of one or more of the existent strategic missile programs; instead, the von Neumann group in February 1954 urged that the established but definitely undernourished ballistic missile program be expanded, accelerated, and extensively restructured.

In many respects the technological bases for the von Neumann recommendations were found in a RAND Corporation study made available to the committee somewhat in advance of its March 1954 publication date. RAND argued that developing an intercontinental ballistic missile was technologically feasible and that the task could be completed in much less time than the 12 years remaining in established schedules. Reduced warhead weights and improved warhead effectiveness represented two of the major reasons for RAND's optimism: a lighter warhead made a smaller, less complex, less expensive missile conceivable; a more effective warhead meant a lessened guidance accuracy requirement, less difficult guidance R&D, and quicker availability. Given recent advances in other important R&D areas, particularly propulsion, it seemed reasonable to expect availability of a deployable missile by 1958 rather than 1963.

The von Neumann group concluded that the technical feasibility of a long-range ballistic missile was no longer in serious doubt, but that existent development organizations and procedures were very

unlikely to serve the needs of ballistic missile development. That judgment certainly stemmed in part from the committee's reaction to Air Staff arguments against acceleration of the ballistic missile program. Senior air officers still were convinced that cruise missiles were better prospects and that new bombers due for delivery over the next three years (B-52 and B-58) were still more desirable.*

The von Neumann group -- and Gardner -- took quite another view of the problem. They had no illusions about the efficiency of long-established development patterns; they felt that the existent accuracy requirements for ballistic missiles were preposterous; and they were convinced that both manned and unmanned bombers could easily be made obsolete by moderate improvements in air defense systems. In any case, the "deterrence" strategy implicitly subordinated high accuracy requirements to "city busting." In the absence of good targeting information, any missile exchange would involve the Americans in "city busting" whatever their inclinations, so extreme target accuracy was an illogical requirement. All in all, then, the von Neumann group and Trevor Gardner were agreed on the need to develop a ballistic missile quite different in many respects from those hitherto sponsored by the Air Force, and to separate the development effort from those being conducted by the regular air establishment, thus insulating it from prospectively hostile influences.

For practical purposes the original Atlas program disintegrated once Trevor Gardner had obtained Secretary Talbott's agreement to the revised objectives. Atlas specifications were extensively overhauled between March 1954 and January 1955, by which time new contracts were being let. So was the organizational structure.

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*The Air Staff succeeded in preserving both Navaho and Snark, although the latter, in particular, was held in low regard both by the von Neumann committee and by the Air Research and Development Command. It may also be recalled that the B-58 as originally laid down was designed primarily as the carrier of an air-launched missile that was to be developed as an integral of the total B-58 system.

The experience of conducting development under few organizational constraints gave the resultant ballistic missile program a character unique in several respects. "Management," as a separate function, was contracted out for the first time. ("Management" had been contracted for as part of weapons development package since 1951, but always before the "management" contractor had also been responsible for design and fabrication of the "system.") Direct access to the secretarial decision level was another innovation that stemmed from the von Neumann-Gardner recommendations, as was a general exemption from decision review that marked operation of the Atlas program office in the years between 1955 and 1960. The effect of these and other novel procedures was to free the missile programs from the inhibitions of operation in a conventional military environment, although in time the "normal" establishment adopted many of the more obvious characteristics of the missile development programs, thus bringing into being a new set of conventions for the conduct of military research and development.

Perhaps most important to subsequent technical progress, each of the principal subsystems of the intercontinental ballistic missile was supported by at least one "back up" development as insurance against failure or unacceptable delay in the primary development. The only unalterable program goal was to develop and deploy as rapidly as possible a missile that satisfied the central specifications. And those specifications reflected not only the technology that had emerged in the eight years since conception of the long-range ballistic missile, but the relatively new concepts of utilization expressed by Admiral Radford and Secretary Dulles. Significantly, only 20 to 40 missiles were originally scheduled for deployment and at no period before 1958 did the ballistic missile policy group seriously recommend to Air Force headquarters that more than about 200 missiles be sent to operational sites. Expense was one consideration, of course, for it was early evident that intercontinental ballistic missiles would cost much more than other air weapons of the time. But the assumption that the missiles would constitute an ultimate deterrent, invulnerable

to interception, certainly had an effect on procurement plans. Such missiles as were early designed could not survive attack. They had to be fired, then, as soon as a massive attack on the United States had begun or -- if the Radford-Dulles doctrine were to be taken at face value -- as soon as the Eastern Bloc had taken any action that called for massive retaliation. Whether utilization plans actually extended to such a contingency is uncertain. It does not seem probable.

Arguments about the credibility of deterrence have become commonplace in the years since 1957, when the Soviets first demonstrated their possession of a ballistic missile capability. Some objections to massive retaliation doctrines arose in the conviction that a nation wholly committed to them would be impotent in the face of repeated small provocations that could not morally justify recourse to nuclear weapons. Others, as early as 1950, grew from the conviction that any resort to nuclear weapons would doom all of humanity. The latter view was the motive for one set of proposals (first voiced by Eugene Rabinowitch in the Bulletin of the Atomic Scientists) that the United States develop a non-nuclear striking force capable of intervening effectively in situations where the use of atomic weapons was obviously inappropriate.* Had either the credibility issue or the call for what was later named "a graduated response" been sufficiently influential in the early 1950s, it seems very doubtful that the missile program proposals of 1954 would have been approved: ballistic missiles of the sort then projected could have been used only for massive retaliation (or first strike). In all probability, something akin to the high-accuracy, small-warhead concept of 1950-1953 would have emerged -- tied to a then-unfillable requirement for precise targeting information. In that case both the development schedules and the performance requirements of 1950-1953 would have been more sensible than any alternatives, regardless of technological forecasts.

One of the most interesting consequences of the 1954-1955 actions was the creation of a relatively influential organization with no

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*Bulletin of the Atomic Scientists. July 1950, p. 217.

purpose of being except to induce more widespread acceptance of the missile thesis. In 1955 Secretary Wilson approved the development of an Air Force intermediate range missile (Thor) based on Atlas-derived technology and an Army-developed intermediate range missile evolved from Redstone (Jupiter). Both ultimately were deployed in England (Thor), Italy, and Turkey (Jupiter), but under the operational control of the Air Force. The introduction of Thor and Jupiter represented nothing more than a hedge against delays in the availability of Atlas, although it also permitted the United States to put into the field weapons generally equivalent to the early medium-range ballistic missiles the Russians had begun to deploy in 1958.

Of considerably greater moment was the 1956 decision to develop a second-generation intercontinental ballistic missile -- Titan. Incorporating many of the "insurance" subsystems originally programmed in support of Atlas, Titan was intended to provide not only a more sophisticated and powerful missile than Atlas, but also one that could survive attack. It was, in essence, an early recognition of the need for a missile system that could "ride out" an assault and be used for later retaliation, an ability almost entirely lacking in the Atlas systems then being developed. But Titan for some years remained very much in a subordinate role, partly because it did not come along as rapidly as had been anticipated, and partly because it was competing with improved versions of Atlas that evolved from the first conception.

In March 1958 the Department of Defense authorized the Air Force to proceed with development of the "117 L System," a reconnaissance satellite.* Discussions of the rationale for and advantages of satellites had begun as early as 1946, chiefly at the instigation of The RAND Corporation and the Navy Bureau of Aeronautics. Although there was considerable enthusiasm for satellite development at low levels in the Air Force, no serious satellite work was undertaken until the

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*Loyd S. Swenson, Jr., James M. Grimwood, and Charles C. Alexander, This New Ocean: A History of Project Mercury (NASA, Washington, 1966), p. 79.

United States committed itself to an International Geophysical Year satellite in 1955 -- and then the commitment was almost an afterthought. Apart from the 1958 announcement and several subsequent informal mentions of the "117 L System," little was made of the military implications.* But those implications, though not widely discussed, were rather obvious. Because a reconnaissance satellite promised to be better at precisely locating key targets than were aircraft, it partly resurrected the earlier justification for high-accuracy guidance, even though continued improvement in warhead designs made the extreme precision of the 1950 requirements less essential. Yet if the Soviets also hardened their missiles, any shift from "city busting" to counter-missile targeting could require both high output warheads and highly accurate delivery modes.

Even though Atlas and Titan were, by a process of normal technological evolution, moving in the direction of more comprehensive military utility, the reaction to Soviet Sputniks of late 1957 must be credited with having precipitated deployment decisions of 1958 and with motivating the production accelerations of that year. To an increasing apprehension of the great cost of such missiles, however, must be credited the inspiration for the third of the major intercontinental missile systems -- Minuteman.

Minuteman was the first Air Force missile to exploit fully the remarkable advances in electronics miniaturization of the 1950s. It

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*The only early public acknowledgment of American interest in earth satellites was brief mention of research efforts by Defense Secretary J. V. Forrestal in the First Annual Report of the Secretary of Defense (Washington, 1948), p. 129. RAND's first report to the Air Forces was Preliminary Design of an Experimental World-Circling Spaceship (Douglas Aircraft Company, Project RAND, May 1946). An excellent account of the early proposals and their fate is R. Cargill Hall's "World-Circling Spaceships: Satellite Studies in the U.S. during the 1940's," the winning essay in the Robert H. Goddard Historical Essay Competition for 1962. It was printed in Technology and Culture, Vol. IV, No. 4, 1963.

was also the first to exploit warhead miniaturization, another advance of the period. But it was not alone in exploiting these developments, because the Navy's Polaris missile put into use very nearly the same technology. And they demonstrated their operational capacity only six months apart, Polaris in July 1960 and Minuteman in February 1961.

Both Minuteman and Polaris had their origins in solid-fuel rocket research that extended back into the early 1940s. The "breakthrough" for each came in 1955 with demonstrations that large-grain, double-base solid propellants could be reliably ignited and burned. The Navy reacted almost at once because what was then called the "solid-fuel Jupiter" was a far more attractive shipboard missile than any liquid-fuel rocket could ever be. The signal for concentration on what was shortly to become Polaris was a suggestion by Edward Teller that the Navy should design toward the sort of small warhead that would be available in the 1960s rather than the much bulkier warheads then being scheduled for the "solid-fuel Jupiter." By December 1956 Rear Admiral William Raborn had obtained Defense Department approval for separate development of Polaris and the Navy had withdrawn from its earlier joint program with the Army Ballistic Missile Agency. With abandonment of the joint program the Navy also committed itself to submarine launch stations. By March 1957 the Navy's Special Projects Office had settled on the general specifications of the missile, the submarine, the undersurface launch system, and related components. Acceleration of the original program and substantial funding authorizations followed Sputnik. Cutting rather more than two years from the earlier schedules was achieved by compressing schedules, eliminating some test sequences, and by relaxing both the range and accuracy specifications.*

Minuteman had a less hectic gestation period, partly because it was in the awkward position of being competitive with the more advanced

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*Wyndham D. Miles, "The Polaris," in The History of Rocket Technology, pp. 162-174. See also FBM Fact Sheets (Navy Special Projects Office, Washington, various dates) which contain in capsule form most of the unclassified information on Polaris.

liquid-fuel ballistic missiles being developed by the Air Force. The peculiar situation of Minuteman advocates as late as 1957 was closely analogous to that of Atlas patrons half a decade earlier: essentially all the critical uncertainties of technology were reasonably well in hand and from the standpoint of national strategy there were excellent reasons for starting intensive development of the missile, but activating a full-scale development program would inevitably cause a diversion of effort from other programs to which the Air Force had commitments. Rivals to the Atlas had been the strategic bombers and the cruise missiles; for Minuteman the rivals were Atlas and Titan, only then entering their flight test stages. Before Sputnik cut the purse strings, Minuteman could have been developed only at the price of limiting expenditures on one of the larger liquid-rocket missiles.

Minuteman promised to overcome the major objections to Atlas and Titan in being a low-cost weapon that could be produced with less difficulty than its predecessors. Moreover, being designed from the first for launch from heavily armored underground sites, it offered advantages in survival potential. Finally, because of its solid-fuel propulsion system it would be a quick reaction missile with a lower possibility of early obsolescence.*

The effect of the Sputnik furor of late 1957 and of the political squabbling that sputtered through the next three years was acceleration of the production of early model Atlas, Thor, and Jupiter missiles and accelerated development of Polaris, Minuteman, and Titan. Other

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*Titan II, which provided many of the advantages of Minuteman, was only in the study stage in 1957. There were later arguments that Minuteman was a cheap missile with all the capabilities of Titan II -- precisely the reaction that Air Force missile project people had feared when Minuteman was approved for development -- but Titan II's ability to boost much greater payloads than Minuteman served to insure its development and eventual deployment. As noted below, Titan II was the only liquid-fuel ballistic missile to be retained in the operational inventory after the Johnson Administration's missile program overhaul of 1964 -- surely an unexpected fate for a missile that barely squeaked through production approval.

missiles, the tactical fighter force, and to a lesser degree advanced strategic bomber programs mostly paid the bill. The acceleration decisions were made feasible by the pace of technology -- which certainly had been more rapid for ballistic missiles than for weapons contemporary with them. But the decisions probably would not have been made as they were if the Soviet Union had not provided first-rate motivation: an unmistakable threat. The whole missile gap controversy that erupted in 1957 and continued through the Presidential campaign of 1960 was in some respects a continuation of the arguments that brought on the 1958 program expansion. Notably, however, the very existence (or pending existence) of the missiles authorized in 1958 served to inhibit consideration of alternative strategies for employing missiles, or of variant national strategies that exploited the new technology embodied in the second generation missiles, particularly Minuteman and Polaris. Both were initially treated as somewhat less vulnerable descendants of the weapons originally laid down to enforce the doctrine of massive retaliation.

As noted earlier, alternatives to massive retaliation -- or at least proposals for creating and improving alternative means of responding to threats from the Soviet world -- had been advanced as early as 1950. Extreme reliance on air power for deterrence had provoked debate within the Joint Chiefs of Staff from the time of initial statements of the Radford-Dulles philosophy, with the Army generally ranged against the Navy and the Air Force. By late 1954 a general discussion of desirable national strategies was in progress, a debate to which Henry Kissinger, Bernard Brodie, William Kaufmann and Arnold Wolfers were early contributors. Their chief argument was that unlimited nuclear warfare should not be treated as the sole possible outcome of a direct confrontation between the two great nuclear powers. In November 1954 Secretary Dulles carefully explained that no such single course had been implied by the positions he and Admiral Radford had earlier taken. In the circumstances it would have been very difficult to expand, with precision, the statement that general war need not inevitably result from escalation of local war. Implications were necessarily vague.

Early in 1956 General Maxwell D. Taylor, then Chief of Staff of the Army, formally urged the Joint Chiefs of Staff to endorse a strategy of flexible response rather than massive retaliation. He was opposed by Admiral Radford, who favored (through mid-1956, at least) absolute reliance on strategic weaponry entrusted to the Navy and the Air Force. Radford was not motivated alone by the continuing and acrimonious arguments within the Joint Chiefs organization,* but also by the mounting discontent being expressed, mostly in books and articles, within the community of scientists -- social, political, and physical.

Although written before Sputnik touched off the new force structure row in government, Kissinger's Nuclear Weapons and Foreign Policy and Robert Osgood's Limited War focused considerable attention on the strategy policy issues that arose in consequence of the Soviet achievement. Kissinger actually was arguing the probability of limited nuclear war and the logic or preparing for it rather than making a case for expanded conventional war capability, but his thinking and the subsequent expansion of his thesis by himself and others did much to center attention on the main issues.**

Bernard Brodie's Strategy in the Missile Age, published in 1959, was the first comprehensive statement of the need for a broad range

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*Such arguments were rarely brought on by abstractions, rather they were expressions of a very basic disagreement about how defense funds should be allocated. Since any war is necessarily fought with the weapons on hand at its beginning, the apparently parochial disagreements on sharing the budget had a direct bearing on strategic concepts. In essence, tactical air and regular ground forces could not be used at a low level of confrontation if they had not been equipped and manned. And through the mid-1950s strategic weapons carriers had first call on funds. It should be recalled, in this connection, that during the 1950s funds were allocated by service, and within each service by function. Any expressed change in strategic concepts or emphasis was meaningless unless it was accompanied by the funds needed to buy the equipment on which its application depended. Although all too obvious, that circumstance is sometimes overlooked in the heat of strategy debate.

**Kissinger and Osgood brought out their books shortly before the October 1957 appearance of Sputnik I.

of responses to various categories and levels of threat. Herman Kahn's On Thermonuclear War, which appeared the following year, was a less orderly but more provocative statement of the central issues.*

The importance of these works lay not so much in what they said as in the fact that the concepts they expressed clearly influenced the attitudes of President Kennedy and his principal advisers. Kennedy came to power in January 1961 after a narrow victory in a campaign marked by more meaningful debate about national goals than any in American history. The President enunciated a new set of national strategic principles embodying graduated response and Defense Secretary Robert McNamara subsequently committed the armed forces to a counter-force strategy. Whether these were lasting policies, and what their long-term effects might be, remained for the future and its events to decide. But the strategy decisions had an immediate impact on the ballistic missile question. Both Minuteman and Polaris were given higher priorities and the quantities of each scheduled for the strategic inventory were very substantially increased. Thor and Jupiter were ordered removed from their European emplacements** on the grounds that they had outlived their usefulness, that the Polaris submarines could do whatever Thor and Jupiter had been scheduled to do without providing such attractive targets. The subsequent decision to dispense

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*There is a vast literature, dating mostly from the 1957-1962 period, on the problems created by massive retaliation as a national policy -- and particularly as a sole national response to challenge. Morton H. Halperin's Limited War; An Essay on the Development of the Theory and an Annotated Bibliography (Cambridge, 1962) is an excellent source for information on the thinking of the period. Urs Schwartz, American Strategy: A New Perspective (Doubleday, Garden City, 1966) briefly summarizes the trends of American strategic thinking from 1945 to 1965. Brodie's book remains the best general treatment of the pre-1960 years.

**Kennedy ordered the removal of the intermediate range missiles early in 1962, encountered passive resistance from the services, and in mid-1962 reemphasized his desires. He was surprised (and angered) to discover that they were still in place at the time of the Cuban missile crisis in October 1962. See Roger Hilsman, To Move a Nation (Doubleday, Garden City, 1967), pp. 201-204.

with all of the liquid fuel missiles except Titan II was based on much the same grounds. None of the withdrawn missiles had much second-strike capability and they represented targets that could induce a missile-armed opponent to strike first, thus touching off the sort of spasm war the graduated response policy was designed to prevent. The fact that technology had come along so rapidly during the previous decade made the first generation missiles as obsolete as B-17s. And unlike aged aircraft, nuclear-armed missiles were not suitable for fighting local wars.

SOME INFERENCES

The ballistic missile decisions of the years 1945-1964 have a peculiar intrinsic interest, not merely because of their enormous aftereffects, but also because of the oddly individualistic views of cause and effect held by each of the several groups involved in those decisions. Perhaps the most striking indication of evolutionary change over the whole period is that by 1963 ballistic missiles were the chief instruments of strategic warfare, established so securely in both doctrine and force structure that alternative weapons proposed for adoption were gravely handicapped. Precisely that situation had existed, inverted, in the years before 1957 when the ballistic missile was the handicapped competitor to the manned bomber, the chosen instrument of the time.

For nearly a decade objections to reliance on ballistic missiles focused on the contention that the missiles were technologically incapable of doing what was required of them. Whether such weapons could be developed at all was argued into the mid-1950s; how dependable they were was argued for at least another five years, into the early 1960s. These were not academic debates, conducted in the isolation of specialized staff offices. They concerned fundamental issues, deeply felt. Even though the advocates of extensive reliance on ballistic missiles ostensibly agreed with the "mixed force" concept that appeared after 1957, they certainly realized that deployment of substantial numbers of missiles would permanently affect the

composition and structure of the strategic forces, working to the ultimate disadvantage of the manned bomber. Between 1951 and 1962, nearly 3,000 jet-powered strategic bombers entered the inventory; by the end of the latter year it was plain that relatively few would be replaced as age and use had their effect. Ballistic missiles had become the dominant weapons. Yet until the certainty of their dominance had become apparent there was relatively little discussion of the consequences of it.

In several intriguing ways the transformation of the American "forces of massive retaliation" during the 1950s is an expression of a thought to which Herman Kahn first gave general circulation. Quoting an unnamed friend, he observed, "It is the hallmark of the expert professional that he doesn't care where he is going as long as he proceeds competently."* Perhaps the advocates of ballistic missiles, and the developers, were not as indifferent to consequences as that epigram suggests, but its relevance seems evident. The analysis on which the 1954 decision to proceed was based had more than competence; it was characterized by astuteness and insight far above the ordinary, but in areas narrow and tightly hedged about. Technological factors, and matters relating to the efficient direction of technology, were its sources; an institution devoted almost exclusively to the exploitation of technology was its stepchild. That institution** devoted itself wholeheartedly to the advancement of the technologies of missilery for most of a decade and at the end of that period had shaped a succession of marvelously contrived weapons capable of being bent to purposes about which few had thought.

The opponents of ballistic missile development, also citing technology in justification, had at best a mistaken instinct for the sorts of arguments that supported their case. They ignored some of the most

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*On Thermonuclear War (Princeton University Press, 1960), p. 7f.

**By which term is meant not merely the Air Force ballistic missile agency, but also the Army and Navy organizations with comparable goals.

pertinent arguments in their favor until technology no longer was a great uncertainty, and missiles were certain to take over some bomber functions, after which they were so awkwardly situated that their cause could not win. The oddity is that early suggestions of the desirability of creating an alternative to massive deterrence were sturdily opposed by those who later had cause to argue for preserving alternative ways of delivering nuclear weapons. Of course the main obstacle to the creation of such alternatives was that a strategy based on the creation and preservation of response options did not find acceptance until one of the interesting options had all but expired.

There was, without question, deep and sincere opposition to the accelerated development of ballistic missiles. It was chiefly effective in the years between 1950 and 1955; thereafter it was overtaken by events. Apart from the grounds of dubious technology, which were most often cited, that objection was based on the assumed lack of a requirement and on the apparent absence of a threat -- though "threat" was taken to be convincing evidence that the Soviets were investing in ballistic missiles, a constraint of questionable worth. It would be difficult to find qualitative or quantitative evidence of other motives, yet there is more than a suggestion in the events themselves that other motives existed.

Some years ago Professor Elting Morison wrote a small essay on the introduction of constant aim gunnery in the Navy. He made five main points about the episode. Briefly summarized (and paraphrased), they are:

1. The essential idea for change occurred in part by chance but in an environment that contained all the essential elements for change and to minds prepared to recognize the possibility of change.
2. The basic elements of the new device were put into application by men interested in the machinery for other purposes or simply interested in the machines themselves.
3. These elements were developed by people interested in the machines at least partly because the machines insured change.

4. Opponents of the new machines were men moved by honest disbelief in the claimed advantages of the devices, concern for protecting other machines with which they identified themselves, and interest in maintaining the establishment with which they were identified.

5. The deadlock between those who sought change and those who opposed it was broken by appeal to a force removed from and unidentified with the mores, conventions, and devices of the establishment.*

Although there are some obvious differences of emphasis, mostly glossed over by paraphrase, the points that Professor Morison made about change in the Navy in the 1890s has some striking parallels in the events of ballistic missile introduction in the 1950s. The key point here is the identification of the opponents of change with relatively small parts of a system of national defense -- in this instance, manned aircraft, and particularly manned strategic bombers. Without going deeply into the sociology or psychology of the phenomenon, it is plain that the people who had grown with manned bombers before and during World War II and who mostly stayed with them through the next decade developed an abiding affection for them, an affection based in some degree on what aircraft meant as a way of life, a symbol, a means of performing their military assignment. With minor exceptions, those who sought to bring on change had no such commitments; they were primarily engineers and scientists of one sort or another and only secondarily airplane commanders. It is not really important whether the opponents of change, or its supporters, consciously recognized the possibility that the adoption of the ballistic missile as a primary means of delivering nuclear weapons would cause the decline or even the disappearance of the strategic bomber.** It is

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*E. E. Morison, Men, Machines, and Modern Times (The MIT Press, Cambridge, 1966), pp. 37-39.

**The impact of missile technology on the tactical forces cannot be ignored, and in some ways it was at least as significant as the effect of strategic missile development on the strategic forces, but the weapons, influences, and institutions were sufficiently different to require separate treatment. As this paper is not the proper vehicle for such an examination, the subject must be passed with this brief acknowledgment.

important, however, that they sometimes acted as if they foresaw that possibility. If there were no other evidence, the fact that bomber supporters repeatedly endorsed the development of air-launched stand-off nuclear weapons carriers when it was clear that the requisite technology was at least as difficult as ballistic missile technology, says something for the case. Characteristically, too, the development of such air-launched weapons, even when they were plainly dependent on technology in which the ballistic missile agencies were most competent, was entrusted to one of the aircraft development institutions.

Such cultural resistance to the innovation represented by ballistic missiles was only one reason for the relatively slow initial progress of the ballistic missile. Failure to take appropriate account of the unpredictability of technology was another. The notion that ballistic missiles would come along in time, in the wake of increasingly complex cruise missiles, dominated R&D planning from 1946 to 1954. Indeed, it was not until 1957, when it became abundantly clear that the Navaho would follow rather than precede the Atlas, that the "orderly evolution" misconception decayed.*

That the development of a unique weapon -- the ballistic missile -- was hampered by attempts to make it conform to patterns set down on the strength of experience with quite different sorts of weaponry -- aircraft -- was acknowledged late. Predictably, there was bitter and protracted resistance to the creation of a separate development agency for ballistic missiles. Perhaps because of the "separate authority" tradition that had roots in the way the Navy designed and built capital ships, the Navy experienced somewhat less difficulty in adjusting to that necessity than did the Air Force. That Air Force resistance adapted rather than collapsed may be deduced from the fact that the present development establishment of the Air Force is totally committed to patterns of program management that were originated in

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*The strange case of the turboprop engine that refused to appear before the "much more complex, much less efficient" turbojet should be recalled as another example of misconstrued technological logic.

response to ballistic missile experience, a consequence that may yet prove to be the most lasting of all those stemming from the early ballistic missile decisions.

Neither the Army nor the Navy seems to have experienced the internal turmoil that attended Air Force introduction of ballistic missiles. The most probable reason is that missiles threatened to displace no established Army or Navy weapons. Instead, they constituted in each instance an addition to the weapons inventory and one that, moreover, gave the Army and the Navy functional responsibility in an area where it previously had been operationally ineffective.* The Navy, in particular, diverted significant sums from other assignments to support of the Fleet Ballistic Missile Program. Although in individual cases the Air Force was obliged to do as much, neither the scope nor the effect of such reprogramming was relatively as great.

Technical feasibility considerations dominated the several key ballistic missile decisions before 1961, although as observed earlier a complex interaction of cause and effect is to be found in each. Yet the possible consequences of new technology seem never to have been well understood by those most immediately concerned. Trevor Gardner and the von Neumann group and General Bernard Schriever, who together were responsible for shaping the course of ballistic missile policy in the Air Force after 1953, showed far less appreciation of the probable effects of successful development than did General Maxwell Taylor or Henry Kissinger or Bernard Brodie, none of whom had any technical competence in missilery at all.

Hindsight is not a very good tool for evaluating past decisions, their ingredients, and their consequences. But it is the best thing of its kind we have. If something applicable to the future can be

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*The Army resisted transfer of operational responsibility for Jupiter to the Air Force even more bitterly than the Navy had earlier resisted cancellation of super-carriers in favor of increased B-36 procurement.

derived from this quick overview of the past, it is that more thorough-going analysis of possible consequences should be conducted as part of a decision process that involves weapons selection. The influence of weapons choice on strategy, tactics, and level of violence is far too important to be subordinated to questions of technical feasibility, general "weapons requirements" definitions, or institutional preferences. If national goals are to be dependent on weapons choices, then the interrelationship of the two must be properly acknowledged. Whatever the intentions or inclinations of military commanders, at any level, they are inhibited in their strategy and tactics alike by the necessity of employing the weapons they have on hand. If such weapons are suited only to a narrow range of applications, strategy and tactics alike will be limited. Technology alone, or its failure, has not yet been decisively important to the outcome of a war -- an accident that promises nothing for the future; a faulty reconciliation of technology with strategic goals, or disrespect for the strategy implications of weapons decisions, could have catastrophic effects.